Test Review № 6

The Stock System . The stock system is a set of rules for naming compounds of metals and non metals. The metal always comes first in the name and the formula. Monatomic metal ions, those consisting of only one type of atom, come in two varieties – univalent and polyvalent. For univalent metal ions, those having only one oxidation state, the name of the ion is exactly the same as that of the element that formed it. For polyvalent metal ions, those having multiple oxidation states, a roman numeral indicates the oxidation state. Polyatomic metal ions, those consisting of more than one type of element such as NH_4^+, ammonium, are found on *Table E*.

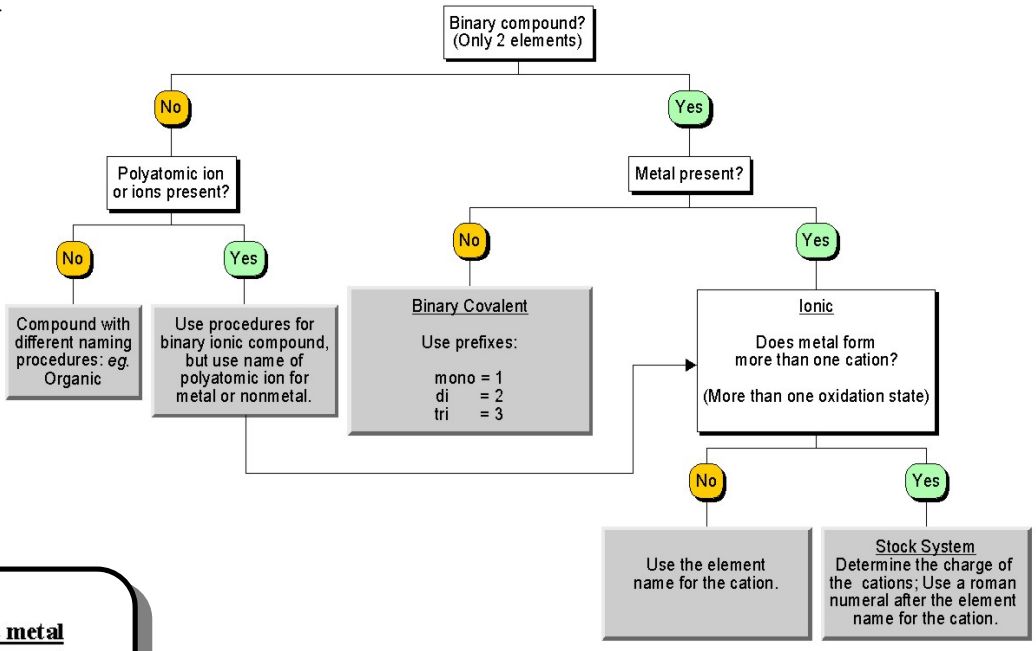
The nonmetal always comes last in the name and in the formula. For monatomic nonmetal ions, delete the last part of the elements name and add "IDE". Polyatomic nonmetal ions, such as SO_4^{-2} (sulfate) or OH^- (hydroxide) are found on *Table E*.

To write the name from the formula, it is necessary to first check the *Periodic Table* to see if the metal is polyvalent. If it is, you need to figure out the oxidation state of the metal by checking to see which one will make the sum of the oxidation states in the compound add up to zero. To write the formulas from the name, you need to look up the oxidation states of the ions, and apply the crossover rule

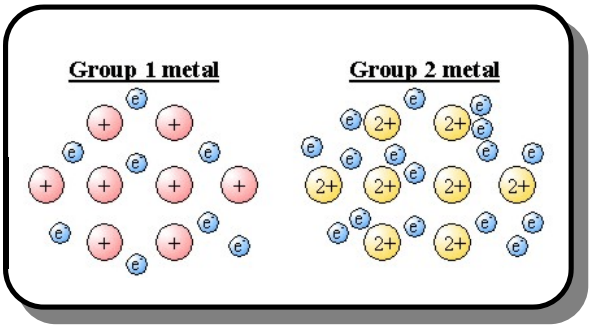
Binary Covalent Compounds. Two nonmetals can combine to form compounds. When two nonmetals combine, they form covalent bonds. The nonmetal with the lower electronegativity behaves like a metal and has a positive oxidation state. In carbon dioxide (CO_2), the carbon behave like a metal while the oxygen behaves like a nonmetal. The metal is written first in the name and the formula. The name of the metal is the same as the name of the element. If there is more than one atom of the metal, the number of atoms is indicated with a prefix. (See the list of prefixes to the right.) The nonmetal is written last in the name and formula..The name of the nonmetal is the same as the name of the element minus the final syllable or two, plus IDE.The number of nonmetal atoms is indicated with a prefix (even when there is only one). Writing formulas for these compounds is easy, because the prefix tells the subscript.

Number of Atoms	Prefix	Number of Atoms	Prefix
1	mono	6	hexa
2	di	7	hepta
3	tri	8	octa
4	tetra	9	nona
5	penta	10	deca

Selecting a Naming System. See below.



Metallic Bonding. Metals have low ionization energies. This means they hold onto electrons loosely. As a result, in a metal crystal, the valence electrons move easily and do not belong to any single atom. Since the atoms in the crystal do not hold on to their own valence electrons, they become like cations in a sea of mobile electrons. The attraction between the cations and the electrons holds the metal crystal together. Because of this, metals are lustrous, flexible, good conductors of heat and electricity, and are solids at room temperature except for mercury.



Types of Bonds. Pure substances can be held together by ionic bonds, covalent bonds, metallic bonds, or intermolecular forces. All ionic substances are crystalline solids. Diamonds are also crystalline solids, but they are made of pure carbon. Large crystals such as diamond or sand (SiO_2) that have a network of covalent bonds are called **macromolecules** or **network solids**. Smaller compounds containing covalent bonds are called **molecules**. The molecules of a substance may be attracted to each other to form solids or liquids by intermolecular forces. These are often called **molecular** compounds. Molecular solids are softer than covalent solids (network solids) and ionic solids, because intermolecular forces are weaker than chemical bonds. If the substance is polar, it is held together by **dipole-dipole attractions**. If the polar substance contains hydrogen atoms attached to either oxygen, nitrogen, or fluorine atoms, it forms especially strong dipole-dipole attractions called a **hydrogen bonds**. Hydrogen bonds are responsible for the three dimensional shapes of many proteins because the large protein molecule folds in such a way that hydrogens in one part of the molecule are close to oxygens or nitrogens in another part of the molecule. Nonpolar molecules are attracted to each other only by the weakest intermolecular forces called **Van der Waal's forces**.

Formula Mass. The masses of ionic and covalent compounds are found the same way–from the formula. The atomic masses of the elements in the compound and the formula are used to determine the mass. The mass determined from the formula is called a formula mass. A molecular mass is a type of formula mass. The terms are sometimes used interchangeably. Formula masses are determined by following the steps in the box to the right. The results are in atomic mass units (amu)

Empirical Formulas. The chemical formula for a molecular compound shows the number and type of atoms present in a molecule. Ionic crystals are a collections of ions. The chemical formula for an ionic compound shows the ratio ions in the compound. The ratio of ions in the formula for an ionic compound is always in lowest terms. A chemical formula in which the ratio of the elements are in lowest terms is called an empirical formula. The molecular formula for glucose ($C_6H_{12}O_6$) is not an empirical formula. All the subscripts are divisible by six. When the subscripts are divided by six, the empirical formula for glucose, CH_2O, is obtained. Some molecular formulas, such as the one for carbon dioxide, CO_2, are already empirical formulas without being reduced.

There are two skills you need to learn in order to work with empirical formulas: Finding the empirical formula from the molecular formula; and finding the molecular formula from the empirical formula and the molecular mass. To find the empirical formula from the molecular formula, divide all the subscripts by the greatest common factor. To find the molecular formula from the empirical formula and the molecular mass.

Finding the Formula Mass

Find the formula mass of $CuSO_4$

Step 1: Look up the mass of each element on the *Periodic Table* and round it off.
Step 2: Multiply each element's atomic mass by its subscript to get the product.
Step 3: Add the products together to get the total

Element	Atomic Mass		Subscript		Product
Cu	64	×	1	=	64
S	32	×	1	=	32
O	16	×	4	=	64
			TOTAL		160

Procedural Steps	Sample Problem
	A compound with an empirical formula of CH_2O has a molecular mass of 90 amu. What is its molecular formula?
Step 1: Determine the empirical formula mass.	Step 1: CH_2O C = 12 × 1 = 12 H = 1 × 2 = 2 O = 16 × 1 = 16 30
Step 2: Divide the molecular mass by the empirical formula mass to determine the multiple.	Step 2: $\frac{90}{30} = 3$
Step 3: Multiply the empirical formula by the by the multiple to find the molecular formula	Step 3: $[CH_2O] \times 3 = C_3H_6O_3$

Percent Composition. Percentage composition is determined by finding the formula mass of a compound, multiplying the mass of each element by 100, and dividing the product by the formula mass of the compound. Use the periodic table to find the masses of individual elements. See the ***Sample Problem*** to the right.

Sample Problem: Find the percentage composition of $MgCO_3$.

Formula Mass		Percentage Composition	
Mg =	24 × 1 = 24	% Mg =	24 × 100 ÷ 84 = 29
C =	12 × 1 = 12	% C =	12 × 100 ÷ 84 = 14
O =	16 × 3 = 48	% O =	48 × 100 ÷ 84 = 57
	84		100

Chemical Change vs. Physical Change. Any change in which no new substances are formed, is only a physical change. When new substances form, there are not only physical changes, there are chemical changes as well. Typically, there are a number of changes that serve as evidence of a chemical change. They are: [1] energy changes; [2] release of gases; [3] formation of a solid in solution or the formation of water; [4] a change in color; and [5] a change in odor. These five changes serve only as evidence of a chemical change. There is no rule that identifies chemical changes unequivocally except that new substances are formed.

Chemical Equations. Chemical equations provide a shorthand way to easily describe what occurs during a chemical reaction. In a typical chemical equation, the reactants are written on the left, while the products are written on the right. The reactants and products are separated by an arrow, or yield sign, which indicates that reactants yield products. (**REACTANTS** → **PRODUCTS**) There are other symbols as well that show the state of the chemicals involved in the reaction. They are: (*s*) or ↓ for a solid precipitate; (ℓ) for a liquid; (*g*) or ↑ for a gas; and (*aq*) for dissolved in water or aqueous. Symbols can also be used to show other factors involved in the reaction such as sources of energy used. These include: Δ for heat or ↑| for light. These symbols are written above or below the yield sign because they are neither reactants nor products. The complete equation shows the identity of the reactants and products using chemical formulas and symbols, the phases of the reactants and products, any energy changes involved in the reaction, and the mole ratios of all the substances indicated by the coefficients. Equations may occasionally be written omitting information about phases or energy changes. The example below shows a complete chemical equation with all the components.

$$2KClO_3(s) \xrightarrow[\Delta]{\mathbf{MnO_2}(s)} 2KCl(s) + 3O_2(g)$$

In the above reaction, the equation shows that the reactant is solid potassium chlorate, the products are solid potassium chloride and oxygen gas, manganese dioxide is a catalyst, and the reaction is endothermic. Symbols for manganese dioxide and heat are shown above and below the yield sign because they are neither reactants nor products.

Answer the questions below by circling the number of the correct response

1. What is the correct formula for copper II nitrate? (1) $Cu(NO_3)_2$ (2) Cu_3N_2 (3) Cu_2NO_3 (4) Cu_2N_3

2. What is the correct name for BaO? (1) barium oxide (2) barium oxygen (3) barium II oxide (4) barium oxalate

3. The formula for zinc hydroxide is (1) $Zn(OH)_2$, (2) $ZnOH_2$, (3) ZnH_2, (4) Zn_2H.

4. The formula for ammonium carbonate is (1) $(NH_3)_2(CO_4)_3$, (2) $NH_2(CO_3)_4$, (3) $(NH_4)_3CO$, (4) $(NH_4)_2CO_3$.

5. The formula for iron II sulfide is (1) $Fe_2(SO_4)_3$, (2) FeS, (3) Fe_2S_3 (4) $FeSO_4$.

6. The name of the compound $CuCO_3$ is (1) copper II carbonate, (2) copper I carbonate, (3) copper III carbonate, (4) copper oxide.

7. The formula for barium nitrate is (1) Ba_3NO_2, (2) Ba_3N_2, (3) $Ba(NO_3)_2$, (4) BaN.

8. The name of the compound H_2S is (1) hydrogen II sulfate, (2) hydrogen sulfate, (3) helium I sulfide, (4) hydrogen sulfide.

9. Which is the compound whose formula is P_2O_5? (1) potassium dioxide (2) dipotassium pentoxide (3) phosphorus dioxide (4) diphosphorus pentoxide

10. The formula for sulfur hexafluoride is (1) SHF, (2) SF, (3) SF_6, (4) S_6F.

11. The IUPAC name for N_2O_3 is (1) dinitrogen trioxide, (2) nitrogen oxide, (3) nitrogen trioxide, (4) dinitrogen oxide.

12. The prefix used to show there are four atoms of an element in a binary covalent compound is (1) quadra, (2) recta, (3) hepta, (4) tetra.

13. Which of the following is a binary covalent compound? (1) Na_2O (2) P_2S_5 (3) Hg_2Cl_2 (4) KI

14. What is the name of $FeCO_3$? (1) iron monocarbon trioxide (2) iron carbonate III (3) iron I carbonate (4) iron II carbonate

15. Which substance will conduct electricity in both the solid phase and the liquid phase? (1) AgCl (2) H_2 (3) Ag (4)HCl

16. What type of bonds are present in a strip of magnesium ribbon? (1) covalent (2) metallic (3) ionic (40 van der Waals

17. Which substance, in the solid state, is the best conductor of electricity? (1) Ag (2) NaCl (3) I_2 (4) CO_2

18. Which substance exists as a metallic crystals? (1) Ar (2) SiO_2 (3) Au (4) CO_2

19. Mobile electrons are a distinguishing characteristic of (1) an ionic bond (2) a metallic bond (3) an electrovalent bond (4) a covalent bond

20. Which element consists of positive ions immersed in a "sea" of mobile electrons.? (1) sulfur (2) calcium (3) nitrogen (4) chlorine

21. Which of the following is an example of hydrogen bonding? (1) $H_2(\ell)$ (2) $I_2(s)$ (3) $CH_3OH(\ell)$ (4) $C_8H_{18}(\ell)$

22. The boiling point increases as you go down the halogen family because of the increase in (1) van der Waal's forces, (2) metallic properties, (3) polarity, (4) covalent bonding.

23. In the family of compounds including H_2O, H_2S, H_2Se, and H_2Te, water has the highest boiling point because it has the greatest (1) van der Waal's forces, (2) metallic bonding, (3) polarity, (4) covalent bonding.

24. Water forms a liquid with a high boiling point due to (1) covalent bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waals forces.

25. Mercury is a liquid due to (1) metallic bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waal's forces.

26. Table salt (NaCl) is a solid due to (1) metallic bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waal's forces.

27. Iodine is a solid due to (1) metallic bonding, (2) ionic bonding, (3) hydrogen bonding, (4) van der Waal's forces.

28. The molecular mass of CO_2 is the same as the molecular mass of (1) CO (2) C_2H_6 (3) SO_2 (4) C_3H_8

29. Which is an empirical formula? (1) C_2H_2 (2) Al_2Cl_6 (3) C_2H_4 (4) K_2O

30. A 60. gram sample of $LiCl \cdot H_2O$ is heated in an open crucible until all of the water has been driven off. What is the total mass of LiCl remaining in the crucible? (1) 18 g (2) 42 g (3) 24 g (4) 60 g

31. Which is an empirical formula? (1) CH_2 (2) C_3H_6 (3) C_2H_4 (4) C_4H_8

32. A compound with a molecular mass of 34 contains hydrogen and oxygen in a ratio of 1:1. The molecular formula of the compound is (1) HO (2) OH (3) H_2O_2 (4) HOH

33. The empirical formula of a compound is CH. Its molecular mass could be (1) 21 (2) 51 (3) 40 (4) 78

34. What is the percentage by mass of bromine in $CaBr_2$? (1) 20% (3) 40% (3) 60% (4) 80%

35. The percent by mass of Li in $LiNO_3$ (formula mass = 69) is closest to (1) 6% (2) 10% (3) 18% (4) 20%

36. The percent by mass of oxygen in CO is approximately (1) 73% (2) 57% (3) 43% (4) 17%

37. The mass in amu of $CaSO_4 \cdot 2H_2O$ is (1) 172 amu (2) 154 amu (3) 136 amu (4) 118 amu

38. What is the empirical formula of the compound whose molecular formula is $C_6H_{12}O_6$? (1) $C_{12}H_{24}O_{12}$ (2) $C_2H_4O_2$ (3) $C_6H_{12}O_6$ (4) CH_2O

39. The percent by mass of aluminum in Al_2O_3 is approximately (1) 18.9 (2) 35.4 (3) 47.1 (4) 52.9

40. A compound contains nitrogen and oxygen in a ratio of 1:1. The molecular mass of the compound could be (1) 14 (2) 16 (3) 30 (4) 40

41. The percent by mass of oxygen in Na_2SO_4 (formula mass = 142) is closest to (1) 11% (2) 22% (3) 45% (4) 64%

42. What is the ratio by mass of sulfur to oxygen in SO_2? (1) 1:1 (2) 1:2 (3) 1:3 (4) 1:4

43. What is the mass in amu of 1.00 molecule of O_2 gas? (1) 11.2 (2) 16.0 (3) 22.4 (4) 32.0

44. What is the formula mass of $CuSO_4 \cdot 5H_2O$? (1) 160. amu (2) 178 amu (3) 186 amu (4) 250. amu

45. What is the molecular formula of a compound whose empirical formula is CH_4 and molecular mass is 16? (1) CH_4 (2) C_4H_8 (2) C_2H_4 (4) C_8H_{18}

46. The percent by mass of hydrogen in NH_3 is equal to (1) $\frac{17}{1} \times 100$ (2) $\frac{1}{17} \times 100$ (3) $\frac{17}{3} \times 100$ (4) $\frac{3}{17} \times 100$

47. The formula mass of NH_4Cl is (1) 22.4 amu (2) 53.5 amu (3) 28.0 amu (4) 95.5 amu

48. An example of an empirical formula is (1) C_2H_2, (2) H_2O_2, (3) C_2Cl_2, (4) $CaCl_2$

49. A 10.0 gram sample of a hydrate was heated until all the water of hydration was driven off. The mass of anhydrous product remaining was 8.00 grams What is the percent of water in the hydrate? (1) 12.5% (2) 20.0% (3) 25.0% (4) 80.0%

50. A compound has the empirical formula NO_2. Its molecular formula could be (1) NO_2, (2) N_2O, (3) N_4O_2, (4) N_4O_4.

51. The percent by mass of oxygen in $Ca(OH)_2$ (formula mass = 74) is closest to (1) 16, (2) 22, (3) 43, (4) 74.

52. What is the percent by mass of oxygen in NaOH (formula mass = 40.)? (1) 80. (2) 40. (3) 32 (4) 16

53. A compound whose empirical formula is CH_2O could be (1) HCOOH, (2) CH_3OH, (3) CH_3COOH, (4) CH_3CH_2OH.

54. A compound has an empirical formula of CH_2 and a molecular mass of 56. Its molecular formula is (1) C_2H_4, (2) C_3H_6, (3) C_4H_8, (4) C_5H_{10}.

55. What is the percent by mass of hydrogen in NH_3 (formula mass = 17.0)? (1) 5.9% (2) 17.6% (3) 21.4% (4) 82.4%

56. The empirical formula of a compound is CH_2 and its molecular mass is 70. What is the molecular formula of the compound? (1) C_2H_2 (2) C_2H_4 (3) C_4H_{10} (4) C_5H_{10}

57. The percent by mass of nitrogen in $Mg(CN)_2$ is equal to (1) $^{14}/_{76} \times 100$, (2) $^{14}/_{50} \times 100$, (3) $^{28}/_{76} \times 100$, (4) $^{28}/_{50} \times 100$.

58. What is the percent by mass of oxygen in Fe_2O_3 (formula mass = 160)? (1) 16% (2) 30.% (3) 56% (4) 70.%

59. Which formulas could represent the empirical formula and the molecular formula of a given compound? (1) CH_2O, $C_4H_6O_4$ (2) CHO, $C_6H_{12}O_6$ (3) CH_4, C_3H_8 (4) CH_2, C_3H_6

60. The percent by mass of carbon in CO_2 is equal to (1) $^{44}/_{12} \times 100$, (2) $^{12}/_{44} \times 100$, (3) $^{28}/_{12} \times 100$, (4) $^{12}/_{28} \times 100$

61. What is the percent by mass of oxygen in CH_3OH? (1) 50.0 (2) 44.4 (3) 32.0 (4) 16.0

62. The approximate percent by mass of potassium in $KHCO_3$ is (1) 19 %, (2) 24 %, (3) 39 %, (4) 61 %

63. What is the percent by mass of hydrogen in CH_3COOH (formula mass = 60.)? (1) 1.7% (2) 6.7% (3) 5.0% (4) 7.1%

64. What is the percentage by mass of oxygen in CuO? (1) 16% (2) 25% (3) 20% (4) 50%

65. What is the approximate percent composition by mass of $CaBr_2$ (formula mass = 200)? (1) 20% calcium and 80% bromine (2) 25% calcium and 75% bromine (3) 30% calcium and 70% bromine (4) 35% calcium and 65% bromine

66. Which compound contains the greatest percentage of oxygen by mass? (1) BaO (2) MgO (3) CaO (4) SrO

67. The precent by mass of oxygen in MgO (formula mass = 40) is closest to (1) 16% (2) 40% (3) 24% (4) 60%

68. The fact that burning wood gives off heat is evidence of a (1) change in mass, (2) chemical change, (3) physical change, (4) phase change.

69. A reaction in which heat is given off is (1) exothermic, (2) endothermic, (3) caloric, (4) acaloric.

70. Which of the following is *NOT* evidence of a chemical change? (1) release of a gas (2) change in color (3) change in odor (4) change in shape

71. When silver nitrate solution is mixed with sodium chloride solution, a white solid forms immediately with no noticeable change in temperature. Which of the following is a true statement regarding the observed change. (1) The change is probably only physical because there is no change in temperature. (2) The change is probably only physical because no gas is released. (3) The change is probably chemical because a precipitate forms. (4) The change is probably chemical because the reaction is exothermic.

72. The symbol (aq) after a chemical formula means (1) solid or precipitate, (2) liquid, (3) gas, (4) aqueous or dissolved.

73. In the reaction, $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$, the reactants are (1) AgCl and $NaNO_3$, (2) $AgNO_3$ and NaCl, (3) Ag and Na, (4) Cl and NO_3.

Answer questions 86–87 by referring to the equation below:

$$2KClO_3(s) \xrightarrow[\Delta]{MnO_2(s)} 2KCl(s) + 3O_2(g)$$

74. The symbol Δ under the yield sign indicates that (1) the reaction is exothermic, (2) the reaction is endothermic, (3) a solid precipitate forms, (4) heat is a product of the reaction.

75. $MnO_2(s)$ is written above the yield sign because $MnO_2(s)$ is (1) a reactant, (2) a product, (3) neither a reactant nor a product, (4) both a reactant and a product.

Answers

1. 1	16. 2	31. 1	46. 4	61. 1
2. 1	17. 1	32. 3	47. 2	62. 3
3. 1	18. 3	33. 4	48. 4	63. 2
4. 4	19. 2	34. 4	49. 2	64. 3
5. 2	20. 2	35. 2	50. 1	65. 1
6. 1	21. 3	36. 2	51. 3	66. 2
7. 3	22. 1	37. 1	52. 2	67. 2
8. 4	23. 3	38. 4	53. 3	68. 2
9. 4	24. 3	39. 4	54. 3	69. 1
10. 3	25. 1	40. 3	55. 2	70. 4
11. 1	26. 2	41. 3	56. 4	71. 3
12. 4	27. 4	42. 1	57. 3	72. 4
13. 2	28. 4	43. 4	58. 2	73. 2
14. 4	29. 4	44. 4	59. 4	74. 2
15. 3	30. 2	45. 1	60. 2	75. 3